

CONTRACT No. N00014-94-C-0210 BETWEEN  
the OFFICE OF NAVAL RESEARCH and NEOCERA, INC.

**FIFTH MONTHLY PROGRESS REPORT**  
**dated February 23, 1995**

**1. Introduction**

The goal of this SBIR Phase I project is to establish the feasibility of designing a High Temperature Superconductor (HTS) Superconducting QUantum Interference Device (SQUID) microscope in order to detect defects, and verify customizations and repairs in MCM substrates. The overall goal of this SBIR program is to market an HTS SQUID microscope dedicated to the inspection of MCM substrates in a manufacturing environment. Neocera and its subcontractor, the Center for Superconductivity Research at the University of Maryland, are working collaboratively in this effort.

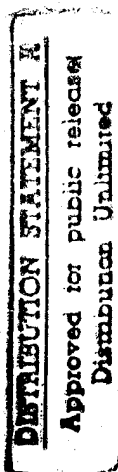
Initial efforts focused on: demonstrating that a room temperature object can be brought sufficiently close to a cryogenically-cooled SQUID sensor to image electrical defects (shorts, opens, voids, particulate contamination, etc.); constructing a room temperature sample stage; and assembling the sensor control and readout electronics. Each of these subtasks have been accomplished.

The secondary effort focused on assembling, testing, and debugging the prototype SQUID microscope, with a cryocooled sensor and a room temperature sample stage. During this period, each of these subtasks were accomplished.

At this time, a fully operational prototype HTS SQUID microscope capable of examining room temperature samples is undergoing functional testing. Figure 1 shows the lower portion of the apparatus, including the room temperature sample scanning stage, sensor extension cryostat, and cryogen reservoir. Nearly all of our Phase I objectives have been achieved or exceeded.

**2. Initial results obtained with the prototype**

The system has been kept cold since the second week of the reporting period. During this time, numerous images of simple test samples have been obtained. The images presented below are all raw and unprocessed. The SQUID electronics have not yet been optimized to obtain the best quality images. Rather, all the main techniques which are envisioned to be required for MCM inspection are being implemented quickly for demonstration purposes. As a result, some of the images show levels of noise, drift, and other features which can be reduced with a little work.



19951031 032

DTIC QUALITY INSPECTED 4



OFFICE OF THE UNDER SECRETARY OF DEFENSE (ACQUISITION)  
DEFENSE TECHNICAL INFORMATION CENTER  
CAMERON STATION  
ALEXANDRIA, VIRGINIA 22304-6145

IN REPLY  
REFER TO

DTIC-OCC

SUBJECT: Distribution Statements on Technical Documents

TO: OFFICE OF NAVAL RESEARCH  
CORPORATE PROGRAMS DIVISION  
ONR 353  
800 NORTH QUINCY STREET  
ARLINGTON, VA 22217-5660

1. Reference: DoD Directive 5230.24, Distribution Statements on Technical Documents, 18 Mar 87.

2. The Defense Technical Information Center received the enclosed report (referenced below) which is not marked in accordance with the above reference.

PROGRESS REPORT #5  
N00014-94-C-0210  
TITLE: NEOCERA, INC

3. We request the appropriate distribution statement be assigned and the report returned to DTIC within 5 working days.

4. Approved distribution statements are listed on the reverse of this letter. If you have any questions regarding these statements, call DTIC's Cataloging Branch, (703) 274-6837.

FOR THE ADMINISTRATOR:

1 Encl

GOPALAKRISHNAN NAIR  
Chief, Cataloging Branch

FL-171  
Jul 93

1995 1031 032

DISTRIBUTION STATEMENT A:

APPROVED FOR PUBLIC RELEASE: DISTRIBUTION IS UNLIMITED

DISTRIBUTION STATEMENT B:

DISTRIBUTION AUTHORIZED TO U.S. GOVERNMENT AGENCIES ONLY;  
(Indicate Reason and Date Below). OTHER REQUESTS FOR THIS DOCUMENT SHALL BE REFERRED  
TO (Indicate Controlling DoD Office Below).

DISTRIBUTION STATEMENT C:

DISTRIBUTION AUTHORIZED TO U.S. GOVERNMENT AGENCIES AND THEIR CONTRACTORS;  
(Indicate Reason and Date Below). OTHER REQUESTS FOR THIS DOCUMENT SHALL BE REFERRED  
TO (Indicate Controlling DoD Office Below).

DISTRIBUTION STATEMENT D:

DISTRIBUTION AUTHORIZED TO DOD AND U.S. DOD CONTRACTORS ONLY; (Indicate Reason  
and Date Below). OTHER REQUESTS SHALL BE REFERRED TO (Indicate Controlling DoD Office Below).

DISTRIBUTION STATEMENT E:

DISTRIBUTION AUTHORIZED TO DOD COMPONENTS ONLY; (Indicate Reason and Date Below).  
OTHER REQUESTS SHALL BE REFERRED TO (Indicate Controlling DoD Office Below).

DISTRIBUTION STATEMENT F:

FURTHER DISSEMINATION ONLY AS DIRECTED BY (Indicate Controlling DoD Office and Date  
Below) or HIGHER DOD AUTHORITY.

DISTRIBUTION STATEMENT X:

DISTRIBUTION AUTHORIZED TO U.S. GOVERNMENT AGENCIES AND PRIVATE INDIVIDUALS  
OR ENTERPRISES ELIGIBLE TO OBTAIN EXPORT-CONTROLLED TECHNICAL DATA IN ACCORDANCE  
WITH DOD DIRECTIVE 5230.25, WITHHOLDING OF UNCLASSIFIED TECHNICAL DATA FROM PUBLIC  
DISCLOSURE, 6 Nov 1984 (Indicate date of determination). CONTROLLING DOD OFFICE IS (Indicate  
Controlling DoD Office).

The cited documents has been reviewed by competent authority and the following distribution statement is  
hereby authorized.

<u>A</u> (Statement)	OFFICE OF NAVAL RESEARCH CORPORATE PROGRAMS DIVISION ONR 353 800 NORTH QUINCY STREET ARLINGTON, VA 22217-5660	_____ (Controlling DoD Office Name)
_____ (Reason)	DEBRA T. HUGHES DEPUTY DIRECTOR CORPORATE PROGRAMS OFFICE	_____ (Controlling DoD Office Address, City, State, Zip)
<u>Debra T. Hughes</u> (Signature & Typed Name)	_____ (Assigning Office)	<u>19 SEP 1995</u> (Date Statement Assigned)

Figure 2 shows a magnetic image of 50  $\mu\text{A}$  currents flowing in a wire shaped into a meander pattern. The wire lies along the regions where light meets dark, so that their pathway is clearly discernible. The spacing between the wires is about 1 mm, and the x and y scales on all of these images is in units of millimeters. The separation between SQUID and sample was about 200  $\mu\text{m}$ .

Figure 3 shows a magnetic image of the letters UMCP (University of Maryland at College Park) printed on a very fine scale with a laser printer. The letters are about 0.5 mm high. The ink is magnetic, with the light and dark regions in the image corresponding to the north and south poles of different magnetized portions of the ink. From the FWHM of the sharpest features in the image, we deduce a spatial resolution of about 70  $\mu\text{m}$ . This is consistent with the thickness of the sapphire window ( $\sim 25 \mu\text{m}$ ), the separation between sensor and window, and the separation between window and sample.

Figure 4 shows a picture of fields produced by 100 MHz currents flowing in a wire meander. The wires are at the intersection of the light and dark areas. The shading in the image corresponds to the magnitude of the field because a diode detection scheme for sensing the high frequency fields was used.

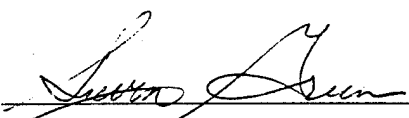
Figure 5 shows an image of fields produced by a 400 MHz current flowing in a wire loop. The loop axis lies in the plane. By taking a series of such images at progressively higher frequencies, it has been found that clear images can be obtained up to about 800 MHz. Above this frequency, considerable blurring of the images occurs. The blurring is due to resonances in the  $\text{SrTiO}_3$  substrate used for the sensor, and is consistent with resonances observed in larger chips. By using a smaller chip with lower dielectric constant, it should be possible to push the operating frequency much higher.

In addition to the images discussed above, eddy current images of patterns etched into copper clad printed circuit boards were obtained. Preliminary measurements of the noise in the SQUID have revealed a flux noise of about  $150 \mu\Phi_0/\text{Hz}^{1/2}$  at 1 Hz, corresponding to a field sensitivity of about 300 pT/Hz<sup>1/2</sup> at 1 Hz. This is remarkably low, especially considering that the SQUID is operated without any magnetic shielding, without a shielded room, and is a high- $T_c$  SQUID. The noise is substantially lower at higher frequencies, so that very sensitive eddy current imaging techniques should be possible.

By <i>per attch</i>	
Distribution /	
Availability Codes	
Dist	Avail and/or Special
A-1	

### 3. Plans for the Next Period

- Continue in effort to obtain samples of MCM substrates from Mayo Foundation.
- Continue full testing of the prototype HTS SQUID microscope.
- Examine the potential limitations of the microscope.

Steven Green 

P.I., Member of Technical Staff

Date 2/23/95

Neocera, Inc.

335 Paint Branch Drive

College Park, MD 20742-3261

301-314-9937

301-405-9256 (FAX)

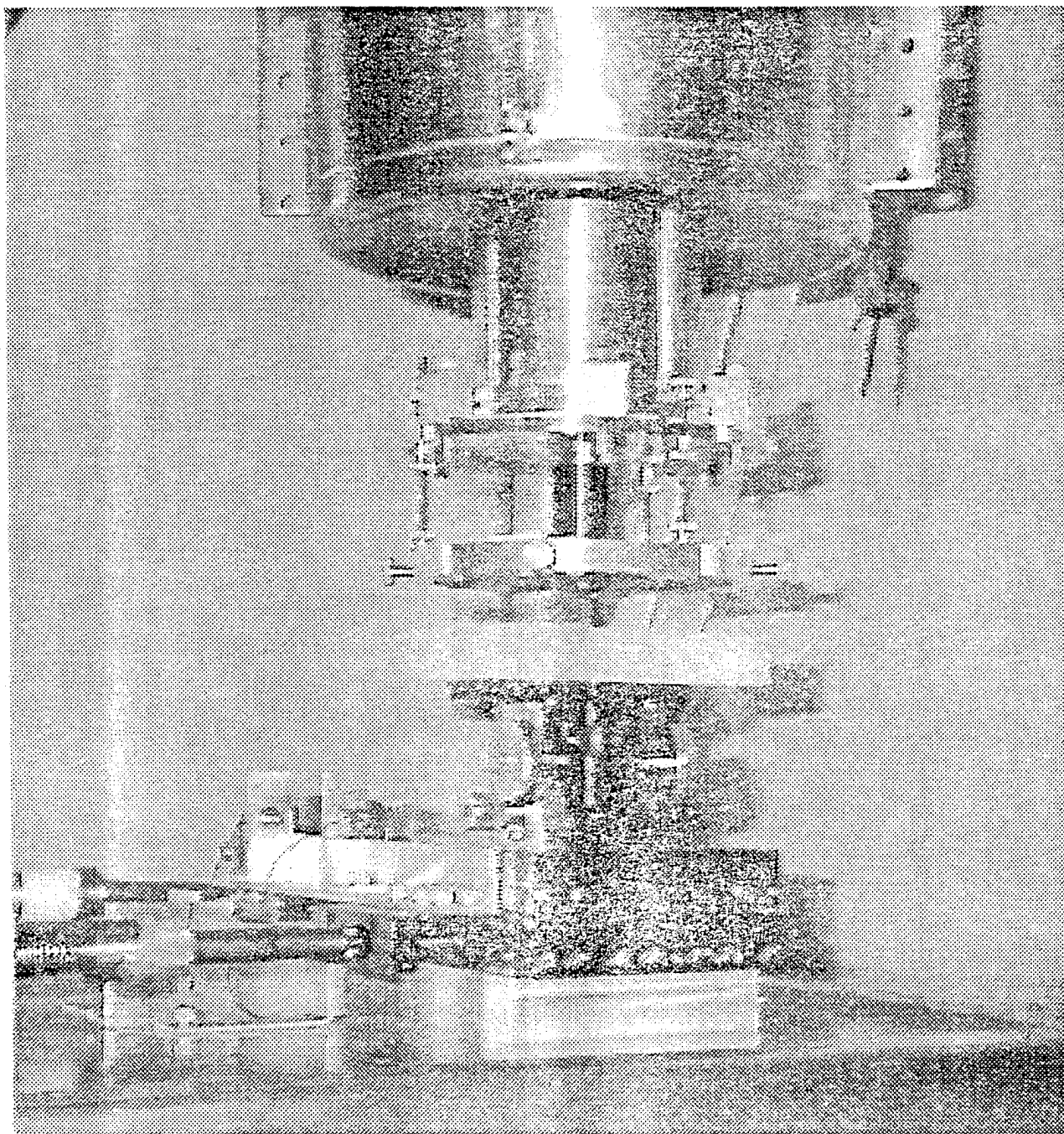


Figure 1. Prototype HTS SQUID microscope with room temperature sample stage.

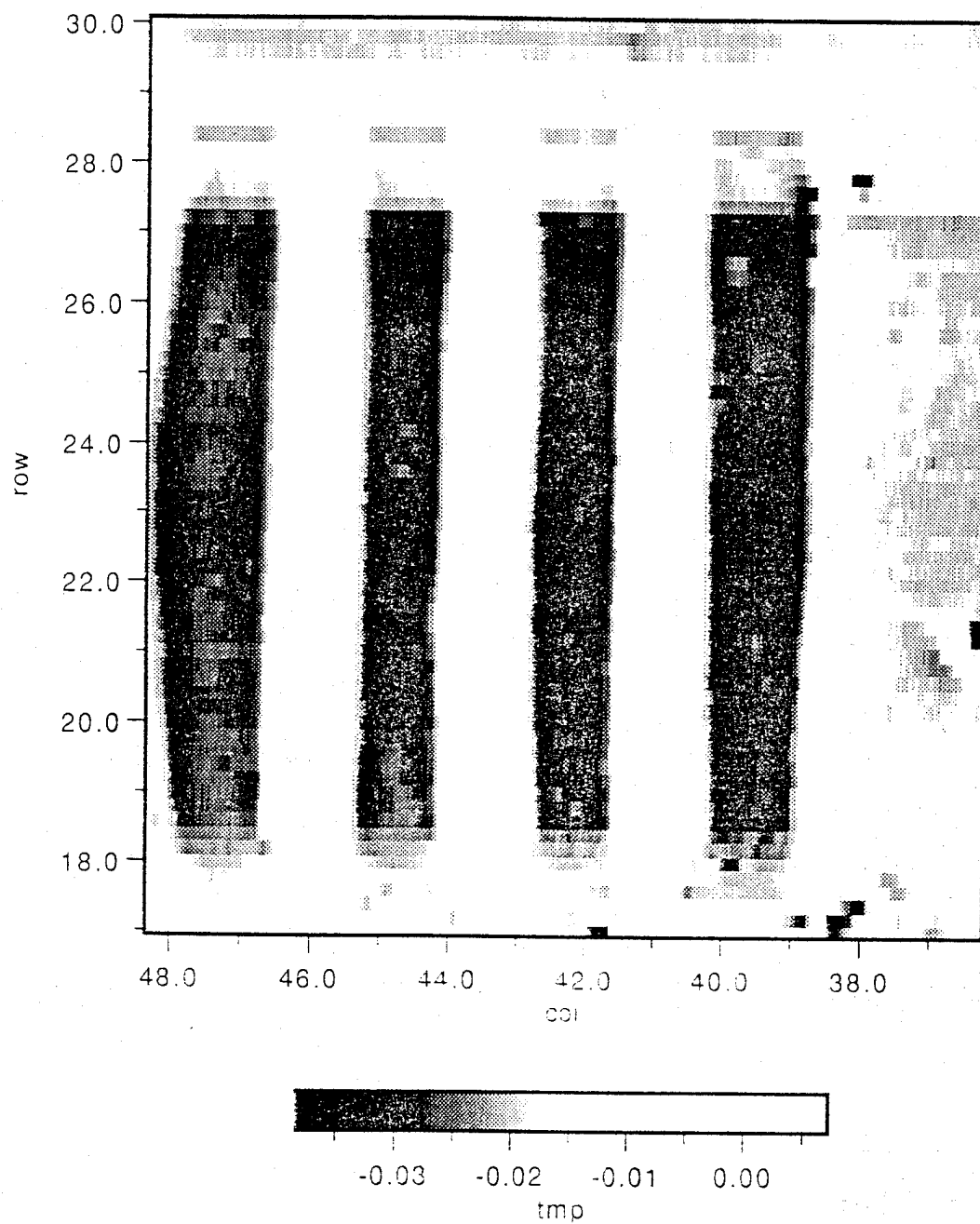


Figure 2. Magnetic fields from meander wire pattern with 50  $\mu$ A dc current.  
X and Y scale in mm.

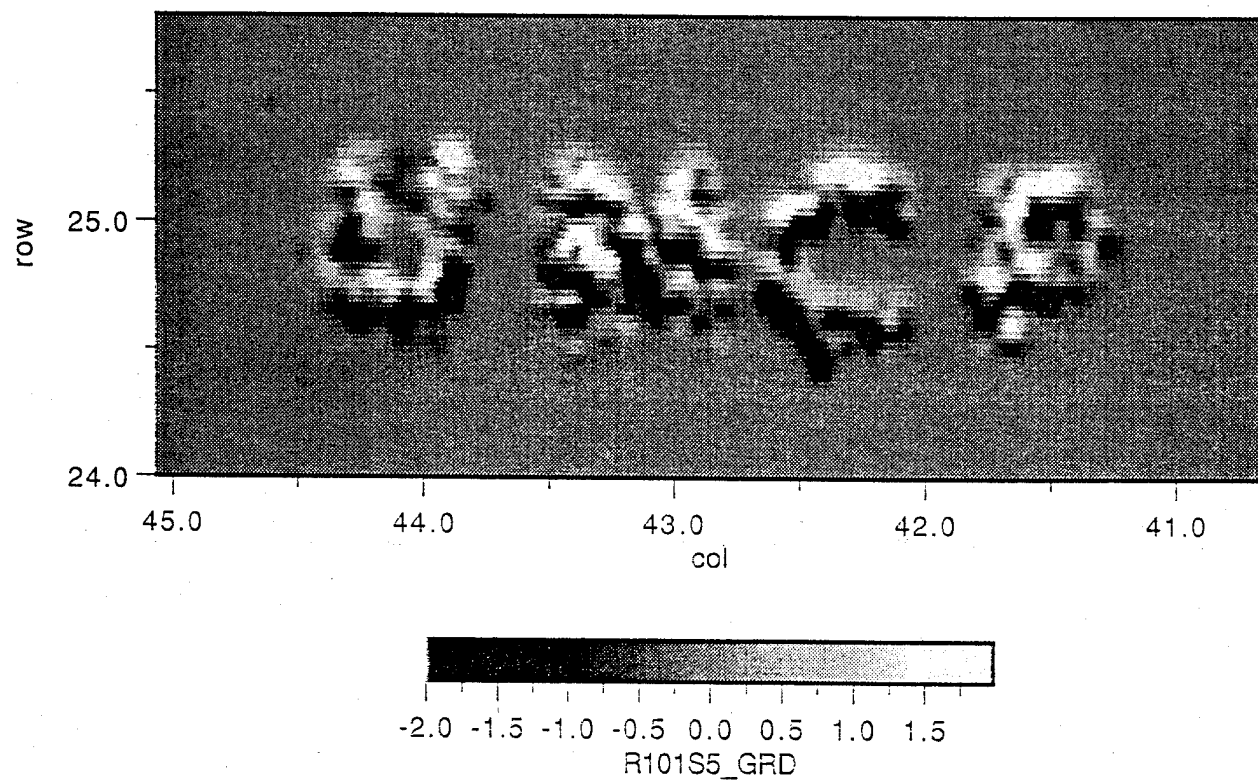


Figure 3. Magnetic image of "UMCP" printed with laser printer ink.  
X and Y scale in mm.

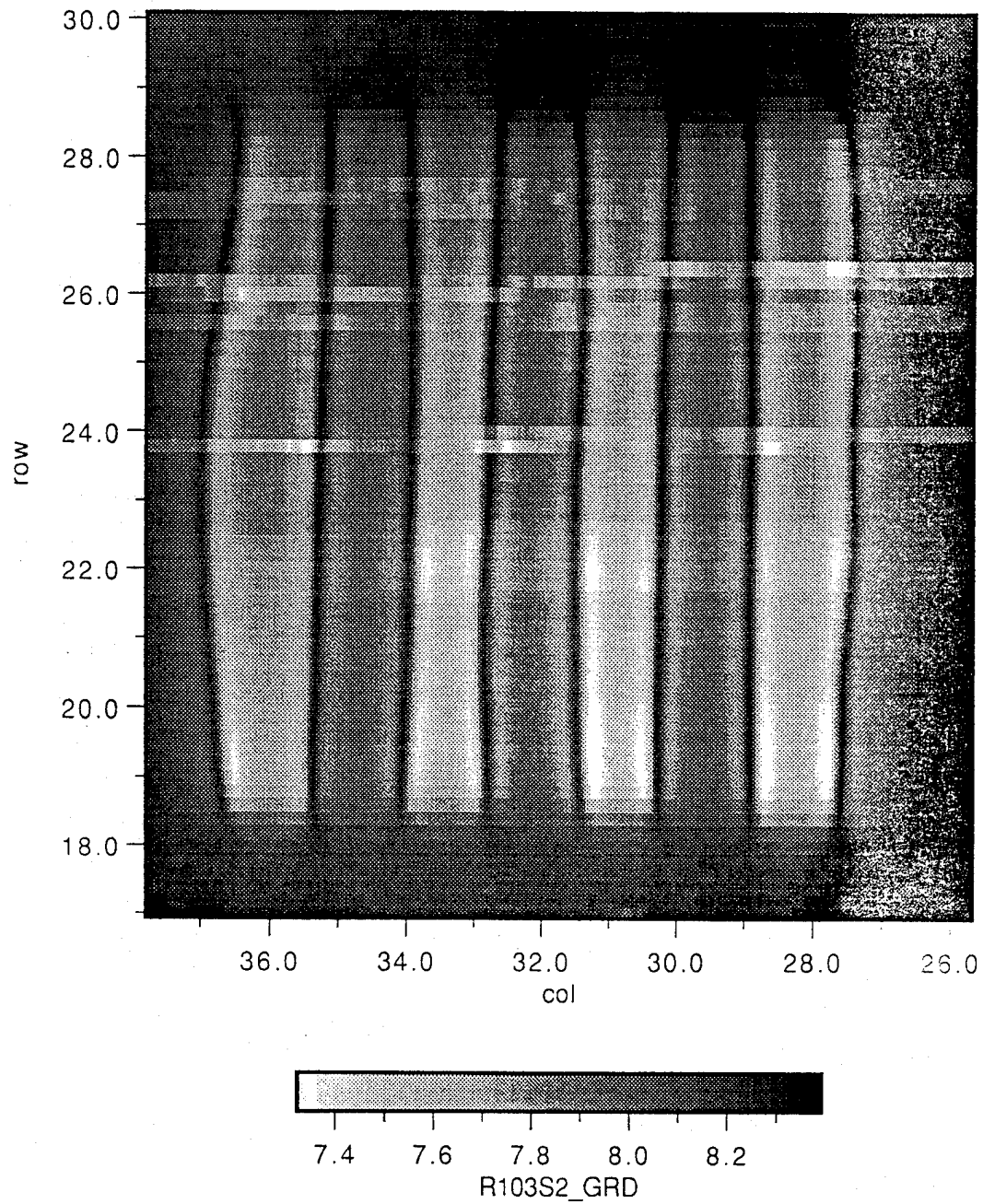


Figure 4. rf image of wire meanders with 100 MHz currents.  
X and Y scale in mm.

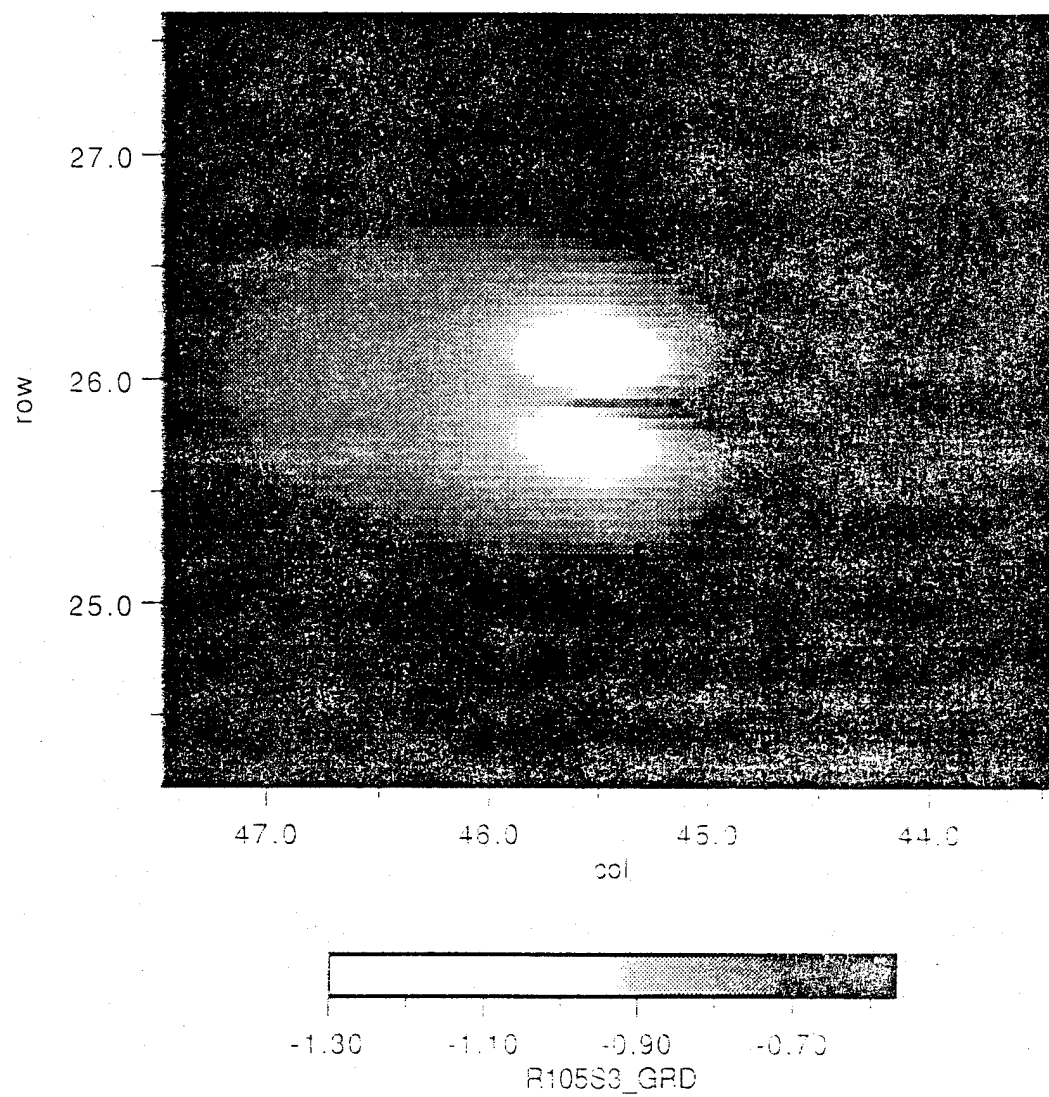


Figure 5. Magnetic image of current dipole loop with 400 MHz currents flowing in the loop.  
X and Y scale in mm.